Resource Ecology and Ecosystem Modeling
Stomach Content Analysis Procedures Manual

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Questions regarding the content of this manual, and comments for its improvement, should be directed to Troy Buckley. Parts of this manual were adapted from the Trophic Interactions Lab Manual produced by Geoff Lang. Several new portions were contributed by Beth Matta, Mei-Sun Yang, Troy Buckley, Richard Hibpshman, and Caroline Robinson. Ashley Forbes and Katie Dodd compiled data for some sections.

List of Appendices

Laboratory Procedures

Introduction

The Resource Ecology and Ecosystem Modeling (REEM) Program's laboratory is primarily dedicated to the task of collecting data on the stomach contents of Alaskan marine fishes. This laboratory is also commonly known as the Food Habits Lab or Trophic Interactions Lab. This Stomach Content Analysis Procedures Manual describes analysis methods, identification techniques, and data entry procedures to be used when processing stomach samples. A companion manual, the Chemical Handling and Sample Tracking Procedures Manual, covers general laboratory safety and the procedures for handling chemicals, tracking samples and other common laboratory tasks. Finalized versions of these manuals, as well as The Alaska Fisheries Science Center's Standard Operating Procedures for Hazardous Chemicals information and The On-Screen Form Manual, are available.

Sample Preparation

All samples being analyzed are contained in 5-gallon buckets of 70% ethanol; formalin is hazardous and must be neutralized before analysts can examine stomachs (see the Chemical Handling and Sample Tracking Procedures Manual). Gloves, safety glasses, and a lab coat are worn at all times in the wet lab, where samples are removed from the buckets and placed on dissecting trays for analysis at the lab stations. Forceps are used when removing a stomach sample from the cloth bag in which it is stored. The stomach, Specimen Label, and any loose prey items are carefully removed from the bag and placed on toweling in a dissection tray. Other fish parts may have also been preserved in the bag to be used for positive predator species identification. These parts (e.g. gill-rakers) are kept with the stomach sample for further examination. The cloth bags are washed so that they can be reused for future stomach collections.

Recording Collection and Predator Data

Once a sample has been prepared for analysis, predator and haul information are entered using the On-Screen Lab Form (Lab Form). Detailed information about the operation of the on-screen lab form is given in the On-Screen Form Manual. The information in that manual is the most accurate and up to date. A data entry session is started by opening the Lab Form on a lab PC. From the opening screen, select 'Enter Data' to open the next screen where the collector's name, season, vessel, cruise, region and predator species are recorded. All of this information is on the Specimen Form associated with the stomach sample. Most of this information is also available on the Specimen Label found in the stomach bag. The Specimen Form is used to verify information from the Specimen Label (if discrepancies exist, the information on the Specimen Label is used, with corrections made and initialed on the Specimen Form).

Once the collection data is entered, 'Pred Data' is selected. This brings up a prompt "Are you going to weigh all prey?" 'Yes' is selected for non-fully trained analyists and those using the Quantitative Method or special procedures. 'No' is selected for fully trained analyists and those using the Qualitative Method. The Pred Data form will open to accept input of haul number, specimen number, predator length (cm), sex, maturity, stomach fullness, total stomach content weight (g), intestine content weight, and comments. Total stomach content weight is entered to the nearest 0.01/0.001g depending on analysis method. Comments entered are not seen by data

analysts but are accessible through raw data tables. The 'Prey Data' opens the Prey Form where all prey specific information is recorded.

Stomach Dissection, Fullness, and Total Content Weight

The stomach contents are dissected out and weighed in the following manner:

1. The esophagus is included with the stomach, but the intestines are removed just anterior to the pyloric caeca. If the intestines will be analyzed, then they are set aside; otherwise they are discarded.

2. A longitudinal incision is made with a scalpel or scissors, avoiding damage to the contents, to reveal the food bolus. At this time stomach fullness is determined and the corresponding code for the degree of fullness (Appendix A) is recorded. Fullness is estimated by considering two factors: the degree of distention of the stomach, and the weight of the bolus relative to the size of the fish. Comparing stomach fullness estimates between analysts will help develop consistency amongst analysts.

3. Excess moisture is blotted from the food bolus with paper toweling; avoiding excessive pressure on the food bolus. Material that is obviously composed of parasites, stomach lining, rocks, or any other non-prey is removed. (These items are not included in the stomach weight, but are noted in the comments section.) The bolus is then weighed to the nearest centigram (0.01 grams) on an electronic balance and this weight is recorded as the "Stomach Weight".

Recording Prey Data

The NODC code, weight (to 0.001g or %volume, depending on analysis method), digestion state, count, life history stage, and parts codes of each prey item found in a stomach is recorded in the "Prey Data" form. (See Appendix B: Prey Codes) The NODC code is a 10 digit number that is unique to each species or taxonomic group. Updated hard copies of the NODC list are printed by clicking the button, 'Print Dictionary' on the "Login Screen" of the Lab Form.

Every prey record (entered NODC prey code) is distinct from other prey records, including separate entries for the same NODC prey codes with different digestion, life history, and/or parts codes. If a new prey item needs to be entered into the NODC code dictionary, there is a tab on the log in page of the lab form that will allow new NODC codes to be added. The code should be found in the NODC taxonomic code book found in the lab. If there is no NODC code in the NODC code book, a new code should be created that follows the numerical pattern for that specific prey.

Stomach Analysis Methods

The Trophic Interactions Laboratory uses two methods in the analysis of stomach contents: the Quantitative Method and the Qualitative Method. The Quantitative Method is used when in-depth information regarding a predator's diet, generally new species or special studies/stations (see Appendix D) is required and when training new lab personnel. The Qualitative Method is used by fully trained stomach analysts for species that vast quantities of detailed data already exists. A detailed description of the procedures for both Qualitative and Quantitative Stomach Analysis Methods is listed below.

Analysis Method	Predator Length (cm)	Total Stomach weight to	Counted and weighed	Prey weight to	Prey stomach volume %	Sub-samples allowed?	Copepods	Minimum Prey Identification
Quantitative	1.0	0.01g	All prey	0.001g	n/a	Yes	n/a	Standard
Qualitative	1.0	0.01g	Prey of Interest	0.001g	estimated	Yes	n/a	Standard
Standard Pollock	1.0	0.01g	Prey of Interest	0.001g	estimated	yes	3 size categories	Standard
Special Stations								Family(?)
Super Special	0.1							Species(?)

Quantitative Stomach Analysis

Prey items are categorized to the lowest possible taxonomic level by using the literature and special techniques discussed later. All prey categories are weighed to the nearest milligram (0.001 g). In Quantitative Analysis, one of four different procedures may be used to sort and quantify the stomach contents. The procedure chosen not only varies with the type and quantity of contents, but also the degree of digestion:

Procedure 1. Used when the bolus is relatively small, or when prey are large and digestion has done little damage to organisms. The stomach contents are separated into taxonomic categories; each category is enumerated, blotted, and weighed separately to the nearest one thousandth of a gram. Any remaining material is either classified as unidentifiable or is subtracted from total content weight if it is stomach lining, fish scales (swallowed in net), parasites, or rocks, etc. This procedure is used most often by new lab personnel during the training period.

Procedure 2. Used when the bolus is relatively large and digestion has done little damage to organisms. If there is only one taxon left after less numerous organisms have been sorted out, its weight is determined by subtracting the weight of all other taxa and non-food items (e.g. parasites) from the total content weight. If necessary, this taxon is then enumerated by estimating the weight of an individual (weighing a known number randomly selected individuals) and dividing this average into the taxon's total weight.

Procedure 3. This method is similar to Procedure 2, but is used when there are two or more abundant taxa left after removing large or less numerous organisms. The remainder of the sample is rinsed and placed in a quartering dish. In one quadrant of the dish, all taxa but one are removed and enumerated (either by estimating or by individually counting). Calculate each prey weight and count (remember to multiply by 4). The remaining prey weight is then arrived at by subtraction; the prey count is estimated or enumerated as above. For example, use Procedure 3 when there are many copepods, amphipods, and/or chaetognaths in a pollock stomach.

Procedure 4. Whether the stomach content mass is relatively small or large, the amount of digestion that has occurred can do great damage to organisms found in the stomach. In these cases an effort is made to determine the total weight of specific prey taxa as accurately as possible. Any combination of the above procedures may be used. It usually requires taking a sub-sample, sorting taxa and their identifiable parts, and categorizing the remaining weight with the major prey taxon found in the stomach. We rarely find it necessary to follow this procedure.

Qualitative Stomach Analysis

Food items are categorized to the lowest possible taxonomic level by using the literature and special techniques discussed later. The main difference between Qualitative Analysis and Quantitative Analysis is the degree to which the sample is sorted. In Qualitative analyses only commercially important fish, crab, and shrimp prey (Prey of Interest) must be sorted out, weighed, and counted. The basic procedure is to sort the prey items into individual taxonomic prey categories, and estimate each category's percentage of the total stomach content volume. Prey of Interest must always be counted, regardless of the number; all other prey items are enumerated only when reasonable (e.g. less than 100). Prey of Interest must be sorted out and weighed to determine their exact weight. There are several ways to approach the sorting of each sample; the procedure chosen varies with the type and quantity of contents and the degree of digestion.

Procedure 1. Used on most stomachs. The prey are sorted to the lowest practical taxon, although not necessarily removed from the petri dish. All fish and crab parts are removed from the sample if present. Fish and crab parts are identified to the lowest practical taxon, counted, and weighed. Once the exact percentage of the total content weight for fish and crab has been determined, the remaining prey items are each assigned percentages based on their estimated volumes.

Procedure 2. Used when the sample consists mostly of fish and/or crab, with just a few other prey items. In some instances it is more efficient to remove the non-fish and/or non-crab prey from the sample and determine its exact percentage by weighing it. As an example, if a stomach contains highly digested crab parts and a few polychaetes and gammarids, it would likely be easier to remove the gammarids and polychaetes rather than try to pick out the many bits of crab. The crab weight would then be determined by subtraction.

Procedure 3. Used on stomachs that have few, large prey, particularly fish and/or crab. If a stomach contains large prey, it is sometimes best to weigh the large prey individually, and then add the individual weights together to arrive at the total stomach weight. This procedure is also appropriate when there are both small and large prey in the same stomach; the small prey can be weighed together, added to the weights of the larger prey, and then sorted and enumerated. Individual percentage volumes can then be estimated after the percentages of the larger prey have been calculated.

Counting Specimens

There may be ambiguity in some samples as to how many individuals of a given taxon are within the stomach. If this ambiguity exists, enter the minimum number that can be proven.

Examples: a) If there are 6 capelin heads and 4 capelin tails in a stomach, the prey count for capelin is 6. *If one of those 4 tails is so large that it is obviously not associated with any of the 6 heads, the prey count is 7 and 2 prey entries must be created.*

b) If there is a pile of vertebrae that looks like it might be from as many as 20 unidentified fish, and you find only 8 precaudal vertebral sections, the count is 8.

c) If there are 77 euphausiid eyeballs among a pile of pink euphausiid mush, the count is 39.

Fish and Crab Prey Size Data

Fish Prey:

Fish that are intact enough to allow an accurate measurement are measured by the stomach analyst. The standard length of each prey fish is measured to the nearest millimeter using calipers, a ruler, or a fish board. Standard length is the distance from the tip of the snout to the posterior end of the hypural bone (the end of the fleshy caudal peduncle.) For grenadier (Family Macrouridae) found as prey, pre-anal fin length should be used. Pre-anal fin length is measured from the tip of the snout to to just before the most anterior anal fin ray.

Standard length can be estimated for fish prey that are mostly intact but are missing part of the head or tail by using the estimated prey length/sex code of 5. This estimated length measurement is further described in Appendix C.

Pollock standard length can be estimated by otolith length when the otolith is in good condition and the pollock is not directly measurable due to digestion; this method is also described in Appendix C.

Crab Prey:

The carapace width at its widest point is measured with calipers to the nearest one tenth of a millimeter. Carapace width is measured on Tanner, snow, cancer, and Korean horsehair crabs.

The carapace length is measured from the eye socket to the center line on the posterior margin of the carapace. Carapace length is measured on king crabs only.

Intestine Analysis

If an intestine weight is not needed or is unavailable, -9 is recorded as the intestine weight.

If the intestine will be analyzed, as is the case for some species of flatfish, use the following procedure: Intestine weights are arrived at by opening the intestine from the pyloric caeca to the sphincter between the intestine and the rectum. The contents are removed, blotted, and weighed on an electronic balance to the nearest centigram (0.01 grams) and recorded. Contents are then discarded.

If the intestine is usable, but the stomach is not, then neither is analyzed.

Determining Net Feeding in the Lab

Net Feeding should be determined in the field, however there are rare occasions where it may be determined in the lab. The presence of a fresh item in the stomach is not necessarily indicative of net feeding. Suspected net-fed prey fish, as observed in the lab, are individually separated from the rest of the stomach contents; net-fed prey is usually a single, fresh item instead

of several items of similar freshness. True "freshly eaten" (i.e. not net-fed) prey fish are usually packed, slightly twisted, and have stomach lining surrounding them. Net feeding typically occurs more frequently in observer-collected stomachs. If a fresh item is found in an observer-collected stomach and net feeding is suspected, the stomach analyst should examine the haul data. If the stomach was collected from a haul over 3 hours in duration and it contains fresh items, net feeding might be a valid conclusion.

If the stomach analyst suspects a prey item from a non-observer-collected stomach is the result of net feeding, they should confer with the data analyst in charge of the area where the predator fish was caught. (The Gulf of Alaska/Aleutian Islands Leader is Mei-Sun Yang; the Eastern Bering Sea Leader is Troy Buckley). If the Leader agrees that the prey item is net-fed, discard that item and analyze the remaining prey. If net-fed prey is the only prey present, discard the entire stomach. Most instances of net feeding will be identified and dealt with in the field; only in very rare circumstances will you encounter this problem in the lab.

If net feeding is suspected but evidence is insufficient to discard the prey item, retain the prey item in the analysis and use digestion code 6.

Procedural Notes Regarding Stomach Content Analysis

- Fish ID Double Checking: One of our main goals is to identify fish and crab to the species level, if possible. Whenever you encounter fish or crab prey that you cannot identify to the family level, AND the prey weight is either more than 10 grams or more than 10% of the total stomach weight, you should have another analyst examine the stomach to double check your findings.

- Fish Eggs: When unidentified fish eggs are encountered, code them as 8735020000, life history = 1, and count them. If clustered, count all of the eggs. Because EtOH clouds the eggs, unidentified eggs should be retained in a vial of 10% formalin for further identification (see the Chemical Handling and Sample Tracking Procedures Manual for proper labeling). The ichthyoplankton laboratory upstairs may aid you in identification of eggs and larval fish. All pollock eggs should be preserved and saved for positive identification.

- POP complex (8826010199) = northern rockfish, sharpchin rockfish, shortraker rockfish, Pacific Ocean perch, and rougheye rockfish. If the prey fish has a symphyseal knob and 5-8 cranial spines, use this code if species identification is not possible.

- When working with longline or pot collected samples, prey that is clearly bait should be discarded prior to determining the total content weight. The weight of the bait can be recorded in the comments section.

End of Bucket Data Check

Once all of the stomachs in a bucket have been analyzed, the analyst should complete an end of bucket data check. To retrieve the data entered for a particular bucket, click on the 'End of Bucket Data Check' button on the first screen of the electronic data entry form. Only predator data (Region, Vessel, Cruise, Year, Quarter, Haul, Predator, Species #, Length, Sex, and Maturity)

are listed. Compare this data with the data printed on the specimen forms and note any discrepancies. If discrepancies are found, forward an electronic copy of the 'End of Bucket Data Check', with the needed corrections to the Data Manager.

Identifying Prey

No single literature source contains keys to all the prey taxa we find in fish stomachs. A list of taxonomic keys that we commonly use to identify stomach contents is compiled in Appendix F. The first section contains references we often use to direct us to broad taxonomic categories. These are also sometimes helpful when identifying prey to species if they cover the appropriate geographic area. The second section contains references that can be used to further identify specimens within broad taxa. Many of these references include keys for regions other than our specific areas of interest, so use them with that fact in mind. We confirm our identifications with a variety of more specific taxonomic references and distribution lists. Unfortunately, many of the characters used for taxonomic categorization are characters easily damaged by digestion. Thus, it is usually necessary to use a combination of references when examining prey items, in addition to the special techniques presented below.

Tables containing identifying characteristics of fish families (Table 1) and of individual fish species (Table 2) have been included in Appendix G, and are also located on the shared drive .

Remember! It is good practice to use more than one physical characteristic to make a positive identification, especially when identifying to the species level.

Special Techniques Used to Identify Prey

When well-digested snails, cephalopods, and fishes are found in stomach contents, a lower taxonomic level is often determined after examining opercula, beak structure, or otoliths, gill rakers and bones. Many references that we use to identify these parts are listed in the second section of Appendix F. We also have a collection of reference specimens that includes bones and gill arches of commonly found fish prey (see next section). In addition, the National Marine Mammal Laboratory (NMML) has an extensive reference collection of cephalopod beaks, fish otoliths and disarticulated fish bones.

Using published information and our reference specimens of bones (particularly vertebral columns, pre-opercle, and postcleithrum,), gill rakers, and otoliths from Alaskan fishes, we can usually identify fish prey to family or even species. Reference specimens of bones are available and can be located by using \Taxonomy\Fish bones.xls (also see the section on Reference Specimen Collection) and pictures of many of these bones are available at \Taxonomy\vertebrae\. A summary of vertebral counts can be found at \Taxonomy\gillarch and vertebrae.xls (worksheet = vert code). Gill raker counts for some commonly encountered prey can be found at \Taxonomy\gillarch and vertebrae.xls (worksheet = raker code). Both vertebral and gill raker counts are available for many fishes in Baxter (1990) and Mecklenberg et al. (2002) (see Appendix F). Training on how to interpret gill raker and vertebral formulae will be provided, but if you have any questions about this, check with Mei-Sun Yang or Troy Buckley.

Many of these reference materials have been collated and displayed online in the Stomach Examiner's Tool. http://access.afsc.noaa.gov/REEM/set/index.php

Minimum Identification Standards

During the standard processing and stomach content analysis of our samples, we require a minimum standard of identification for common prey items that are in good condition. Stomach analysts should also attempt to incorporate these standards for moderately and well digested prey whenever possible.

Porifera (sponge) 3600000000

Cnidaria 3700000000 Determine whether
- Hydroida (hydroid) 3701000000
- Scyphozoa (jellyfish) 3730000000
- Anthozoa (anemone) 3740000000

Ctenophora (ctenophore) 3800000000

Polychaeta (polychaete worm) 5001000000 Determine family.

Mollusca 5085000000 Determine whether
- Gastropoda 5100000000
  - (If you can identify a benthic gastropod to a level where it is clear from the NODC code that it was a benthic prey type, that would be best.)
  - Pteropod 5109000000
    - Thecosomata (shelled pteropods) 5113000000
    - Gymnosomata (naked pteropods) 5125000000
  - Heteropoda (pelagic snails) 5103730000
  - Nudibranchia 5127000000 (sea slug)
- Bivalvia 5500000000
  - (If it appears to be a type of scallop, try to identify it further.)
- Cephalopoda 5700000000 Determine family
  - (When the specimen is very digested, or only a beak remains, it is important to distinguish between Teuthoidea (squid) 5705000000 and Octopoda (octopus) 5708000000 whenever possible)

Crustacea 6100000000 Determine whether
- Copepoda 6117000000 Determine order
  - Calanoida 6118000000
    - Large Calanoida >5mm 6118999991
    - Medium Calanoida 2-5mm 6118999992
    - Small Calanoida <2mm 6118999993

Harpacticoida 6119000000

Mysidacea 6151000000 Determine suborder
Lophogastrida ("deep-water" mysids) 6152000000
Mysida ("shallow-water" mysids) 6153000000
Mysidae 6153010000 (Only family in North Pacific)

Isopoda 6158000000

Cumacea 6154000000

Amphipoda 6168000000 Determine suborder
Gammaridea 6169000000
Hyperiidea 6170000000
Caprellidea 6171000000

Euphausiacea 6174000000 Determine family
Bentheuphausiidae 6174010000
Euphausiidae 6174020000

Decapoda 6175000000 Determine family
Natantia (shrimp) 6178000000
Penaeidea
Penaeidae 6177010000
Sergestidae 6177020000
Caridea 6179000000
Pasiphaeidae 6179050000
Oplophoridae 6179010000
Hippolytidae 617160000
Crangonidae 6179220000
Pandalidae 6179180000
DETERMINE SPECIES & LENGTH
Reptantia 6180000000
Anomura 6183000000 Determine family
Paguridae (hermit crabs) 6183060000
Lithodidae (king crab) 6183080000
DETERMINE SPECIES & LENGTH
Brachyura 6184000000 DETERMINE SPECIES & WIDTH
Cancridea 6188000000
Cancridae 6188030000
Oxyrhyncha 6187000000
Majiidae 6187010000

Marine worms - Determine Phyla
Sipuncula 7200000000

Echiura 7300000000
Priapulida 7400000000

Bryozoa (bryozoans) 7800000000

Echinodermata 8100000000 Determine Class
Asteroidea (starfish) 8104000000
Ophiuroidea (brittle & basket stars) 8120000000
Euryalina (Now Phrynophiuroida = basket stars) 8125000000
Ophiurida (brittle stars) 8126000000
Echinoidea (urchins & sand dollars) 8136000000
Echinacea (urchins) 8144000000
Clypeasteroidea (sand dollars) 8152000000
Holothuroidea (sea cucumbers) 8170000000

Hemichordata (acorn worm) 8200000000

Chaetognatha (arrow worm) 830000000

Urochordata (tunicates) 8400000000
Ascidiacea (sea squirt) 8401000000
Thaliacea (sea salp) 8407000000
Larvacea (larvacean) 8413000000

Fishes 8599999999 Determine species of fish whenever possible at all digestion states.

Reference Specimen Collection

Reference specimens are stored and cataloged by the REEM Laboratory, and can be used for ID verification of prey found in stomachs. Various life history stages (e.g. larval, juvenile, and adult), and parts (e.g. cephalopod beaks, fish bones) of organisms are kept for reference.

Reference specimens are stored in two flammable liquid cabinets. One cabinet is located in the lab (Room 1093), containing all the fish specimens, and the other is located in the storage closet (Room 1088), containing all the invertebrate specimens. Each reference specimen is placed in a small vial filled with 70% Ethanol solution and a label providing the prey name and NODC code, as well as the predator name, location, and year of collection. Each specimen is also barcoded and entered into a database so we can track our reference specimens and the amount of ethanol we are storing in the lab.

Reference lists are maintained in three locations: *check these*

1. a gray binder labeled “Reference Specimen Collection” in the laboratory bookcase
2. on the door of each flammables cabinet
3. \Taxonomy\FishReferences; \Taxonomy\InvertebrateReferences

The protocol for adding new specimens to the Reference Collection can be found in the Resource Ecology and Ecosystem Modeling Chemical Handling, Sample Tracking and Safety Procedures Manual.

When a new prey item is found, its NODC code must be looked up in the master NODC dictionary and added to our NODC list. Any time a new prey item is found, its identification should be checked thoroughly and verified by either Mei-Sun Yang or Troy Buckley, and an example of the specimen saved for the Reference Collection. New prey NODC codes are recorded in the "List of Prey Items" notebook found in the laboratory. Along with the new prey NODC code, the analyst's name, the identification reference used, the scientific name and the common name are recorded. Add new prey NODC codes to the lab dictionary by using the ‘Add new NODC’(?) button on the “Main Page” of the Lab Form.

Other Specimen Collections

The National Marine Mammal Laboratory maintains a thorough specimen collection of cephalopod beaks, fish bones and fish otoliths. These specimens can be accessed by contacting Jim Thomason (Jim.Thomason@noaa.gov). NMML has databases for each collection in Excel format that can be searched and sorted by family, genus and species. We have a hard copy of the “FishBones” list that is kept in the Reference Specimen Collection binder.

Appendix A: Predator Codes

Season Codes:
1 – January – March
2 – April – June
3 – July – September
4 – October – December

Sex Codes:
1 – male
2 – female
3 – unknown/juvenile

Maturity Codes:
0 – not spawning
1 – spawning
9 – no code

Stomach Fullness Codes:
1 – empty
2 – trace of prey
3 – trace-25% full
4 – 25-50% full
5 – 50-75% full
6 – 75-100% full
7 - distended

Appendix B: Prey codes

Digestion State Codes:
1 - stomach empty
2 - traces of prey items
3 - < 50% intact
4 - 50-75% intact
5 - 75-100% intact
6 - no digestion

Life History Codes:
1 – egg
2 – nauplius
3 – zoea
4 – megalops larva
5 – veliger larva
6 – larva
7 – juvenile
8 – adult
9 – combo of larvae, juveniles and adults
A - combo of juveniles & adults
B – combo of larvae and juveniles
C – life history stage unknown (default)
D – polyp
E – cypris
F – copepodid
G – pupa
H – nymph
K – medusa
L – egg-carrying
M – egg case
Q – immature
R – subadult
S – trochophore larva
T – subadult and juvenile
U – mating pair
V – mysis
W – colony
Y – soft shell

Parts Codes:
Blank – whole prey found
1 – different
2 – siphon/foot
3 – shells
4 – legs
5 – setae
6 – chelae
9 – bones
A – heads
B – eyes
C – beaks
D – tails
P – proboscis
L – leg or chelae autotomized

Sex Codes/Estimated Length Codes:
1 – male
2 – female
3 – unknown/juvenile
5 – estimated prey length
6 – fair pollock otolith condition
7 – good pollock otolith condition
8 – excellent pollock otolith condition

Definitions and explanation of how the codes are used.

Digestion Codes:

1. *Stomach empty* – No items found in stomach. This code is automatically entered when using the on-screen data entry form.
2. *Traces of prey items* – This code is used when there are only a few parts left of the prey item because most of the item has been completely digested away. Use this code when you find almost completely digested prey. For example, cephalopod beaks, euphausiid eyes, or fish bones with no flesh remaining.
3. *<50% Intact* – Use this code when extensive digestion is evident but there may be several parts and perhaps some well digested chunks remaining. For example, squid and fish would have some flesh remaining, large crustaceans may be missing parts due to digestion, and it may be impossible to distinguish individual small crustaceans in a slurry of parts.
4. *50-75% Intact* – This code is used very often for prey items that are still partially intact, but remaining portions may be softened due to digestion. For example, fishes would have no exposed skin remaining and parts of the head or tail may be disarticulated, but a majority of the flesh would still be present; large and small crustaceans may have most of the carapace and appendages intact, but have the carapace and internal flesh softened due to digestion.
5. *75-100% Intact* – This code is used for prey items that are in good to almost perfect condition, but often with some damage due to digestion. For example fish are mostly intact, but may be missing some skin or fin rays (usually the first parts of the fish to be digested away).
6. *No digestion* – This code is used only for prey items which are in immaculate condition. Also use this code if you suspect the prey item is a result of net feeding (see "Determining Net Feeding in the Lab").

Life History Codes:

1. *Egg* – Use for fish and invertebrate eggs.
2. *Nauplius* – Earliest crustacean larval stage; three pairs of appendages present (1st antennae, 2nd antennae, and mandibles. (In higher crustaceans, this stage takes place within the egg.)
3. *Zoea* – Larval stage in higher crustaceans; 1st eight pairs of trunk appendages are free of carapace. We usually use this code for crabs.
4. *Megalops* – Later larval stage; we usually use this code for crabs.
5. *Veliger* – Mollusk larval stage; foot, shell, and velum (swimming organ) are present.
6. *Larva* – Use for larval fish and invertebrate larva that do not fit any of the above descriptions.
7. *Juvenile* – Use for juvenile fish and invertebrates.
8. *Adult* – Use when you want to make the distinction that the prey item is an adult.
9. *Combination of larvae, juveniles, and adults* – Use when there are all three in a sample. (Typically it is best to separate out one or more of these categories; hence this code will be used infrequently.)

A. *Combination of juveniles and adults* – Use when there are both (e.g. a mix of juvenile and adult euphausiids.)
B. *Combination of larvae and juveniles* – Use as above.
C. *Life history stage unknown* – This is the default life history code. Use it if you do not know the life history stage of the prey item.
D. *Polyp* – Sessile life history stage of cnidarians; cylindrical body with tentacles at mouth end.
E. *Cypris* – Barnacle larval stage.
F. *Copepodid* – Copepod larval stage.
G. *Pupa*
H. *Nymph*
K. *Medusa*
L. *Egg-carrying* – Use for female invertebrates that are gravid.
M. *Egg case*
Q. *Immature*
R. *Subadult*
S. *Trochophore* – Larval stage of mollusks, annelids, etc. Body is ringed by a girdle of cilia.
T. *Subadult and juvenile*
U. *Mating pair* – Use if male and female eaten together were obviously mating when consumed.
V. *Mysis* – Juvenile mysid
W. *Colony*
Y. *Soft shell (crabs)*

Parts Codes:

Most prey items will not have a parts code associated with them even though the prey items are quite often found in pieces due to digestion.

Parts codes should only be used in one of the two following methods:

- To describe a prey item that was eaten as a part rather than as a whole, and is not merely the result of digestion. (e.g. proboscis, siphon, leg or chelae.)
- To describe a hard part that is left in the stomach as a result of digestion, even though the animal was eaten whole. When codes are used for this situation, the digestion code is usually 2. (e.g. If euphausiids were eaten and all that remains are their eyes, the parts code should be B, and the digestion code should be 2.)

1. *Parts* (*many different…*) – This is used when there is no other suitable code to describe the part that was eaten or the hard part that remains, or when there are more parts than can be described by any one code.

2. *Siphon/Foot* – Used for clam or snail siphons/feet, when they are eaten as a part.

3. *Shells* – Used for mollusk shells, or shell fragments, whether eaten empty or whole; no soft parts remaining due to digestion .

4. *Legs* – Generally used when one or more crab legs have been obviously torn off of the animal, but the entire animal wasn't eaten (i.e. the legs were eaten as parts). Count the number of legs, and enter under prey count.

5. *Setae* – This code is nearly always used for setae that are left as remnants of an animal, not as a part that was eaten by itself, usually from polychaete worms and echiurans

6. *Chelae* – Used when chelae have been picked off of the animal, like the legs code.

9. *Bones* – Used when there are only bones left of the prey item (with very little flesh attached). For example, jaws, vertebrae, and /or individual bones from the head of a fish.

A. *Heads* – Used when only the head of an animal is eaten, most commonly used in association with fishery discards. This code should also be used for polychaete 'feathers'.

B. *Eyes* – Usually used when eyes remain after the prey item has been digested away; most common with euphausiids.

C. *Beaks* – Only used when the rest of the animal has been digested away; most common with cephalopods.

D. *Tails* – Used when only the tail of the animal has been eaten; commonly used with fishery discards.

P. *Proboscis* – Used when the proboscis of an animal has been bitten off; common with echiuruns.

L. *Autotomized leg or chelae* – Used when a leg or chelae has clearly been autotomized rather than just ripped or torn off. (Autotomization is a defense mechanism, and occurs when the prey animal becomes so frightened that it drops its leg, rather than having it ripped off by the predator.)

Appendix C: Pollock Otolith Length / Estimated Length Procedures

Pollock otolith measurement procedure:

Well digested pollock are often not measurable by conventional methods, but when the otoliths are present, the pollock length can be estimated from the otolith length (Sinclair, E.H. 1988. Feeding habits of northern fur seals (*Callorhinus ursinus*) in the eastern Bering Sea. M.S. Thesis, Oregon State University, 94p.).

The first step is to assign the otolith a numeric code representing its condition as follows:

- Poor = Broken or key features are not readily identifiable. These otoliths will not be used.
- 6 – Fair = Completely smooth, sometimes chalky, easily identifiable to species(?).
- 7 – Good = May be worn, but still retains detail at the edges and sulcus.
- 8 – Excellent = Looks as if it was recently removed from the fish, little digestion or dissolution.

If the otolith is determined to be in fair, good, or excellent condition, record the corresponding numeric code in the "Prey Sex" column. The presence of an otolith condition code in the prey sex column will denote that the corresponding standard length was determined from an otolith. Measure the otolith to the nearest 0.1 mm using calipers. The otolith length is defined as the straight line distance from the anterior to the most posterior margin of the otolith; for walleye pollock otoliths this will be the longest straight line measurement available. Enter the otolith length into the Lab Form to initiate an otolith-length-to-standard-length conversion algorithm which calculates the estimated standard length of the prey pollock.

If multiple otoliths are found in a sample, try to determine the number of fish that were represented by those otoliths and take one measurement per fish. If the otoliths appear to be significantly different in size, then it is safe to assume that they are from different fish. If the otoliths are of similar size, try to determine the number of fish by counting backbones, jawbones, or other hard parts, and then make the appropriate number of otolith measurements.

The equations (from Frost, K.J., and L.F. Lowry. 1981. Trophic importance of some marine Gadids in northern Alaska and their body-otolith size relationships. Fish. Bull., U.S. 79:187-192.) used to generate the conversion are as follows:

Otolith length $\leq$ 10.0 mm Fork length (cm)=(2.246 * otolith length (mm)) - 0.51

Otolith length > 10.0 mm Fork length (cm)=(3.175 * otolith length (mm)) - 9.77

Then a conversion factor of 9.26 is used to obtain standard length in millimeters from fork length in centimeters. This conversion factor was obtained from the database of the REFM Trophic Interactions Laboratory.

Estimated Length Procedure:

An estimated length can be recorded for fish and crabs that are slightly damaged or partially digested, and for which an exact measurement cannot be taken. This method may also be used for pollock, but only when the otoliths are missing or are in poor condition. To record an estimated length, enter a 5 into the "Prey Sex" column; then enter the estimated length of the fish or crab in millimeters.

Appendix D: Instructions for Processing Stomachs from Special Stations

1) Weigh (do not estimate volume of) all prey items.

2) Count all prey items.

3) Identify prey to the lowest taxonomic level as before, plus

a. Identify polychaetes to the family level.

b. Identify calanoid copepods to the following three groups:

large-size calanoid (>5.0 mm):	*Neocalanus cristatus,*
	Eucalanus sp,
	Euchaeta sp.
medium-size calanoid (2.0-5.0 mm):	*Calanus plumchrus,*
	C. glacialis,
	C. marshallae,
	C. pacificus
small-size calanoid (<2.0 mm):	*Paracalanus* sp.,
	Pseudocalanous sp.

c. Identify euphausiids to the species level if you can. If there are many species in one stomach and they are too abundant, use a quartering dish to sub-sample the euphausiids, identify them, weigh, and count. Then multiply by 4 to get the total count and weight of different euphausiids.

d. Separate Gammarid amphipods and Hyperiid amphipods.

e. Identify shrimps and crabs to the species level if possible.

4) Measure prey-length for the following:

Prey fish: standard length
Pandalid shrimp: carapace length
Commercial crabs other than king crabs: carapace width
King crabs: carapace length

5) Processing procedures:

a. for zooplankton eaters: e.g. pollock, Atka mackerel, rockfish, etc.
If the stomach contents are too full, use a quartering dish to sub-sample the stomach contents. Sort out different prey groups, identify them, weigh, and count. Then multiply the factor by 4 to get the total weight, count of each individual prey groups.

b. for all other predators: sort the whole stomach contents, weigh, and count the different prey groups.

c. measure all prey fish, commercial crabs, pandalid shrimps; do not take sub-sample data from the prey length measurements, measure them all.

Add Apendix D.1 for instructions for processing stomachs from fish collected from the Bering Sea and/or Chukchi Sea

Appendix E: Performance of the Fully Trained Stomach Analyst

The goal of our system for assessing job performance in the area of stomach content analysis is for analysts and their supervisors to be able to monitor progress against an attainable annual benchmark of production. Easily achievable, daily rates of stomach content analysis have been established for each predator species. The annual benchmark we will use is based on these daily rates, but time spent on other activities is taken into account. In general, time taken for holidays (2 wks), personal leave (5.5 wks), and miscellaneous duties (3 wks), leaves a little more than 41.6 weeks of work in a year. Sometimes special projects (up to 20% of the analyst's time) are assigned, leaving approximately 33.4 weeks per year spent analyzing stomachs.

The points assigned to the predator species reflect their relative difficulty and the amount of time it takes to process them. All full stomachs from special stations, where the analysis methods described in Appendix D are used, should be assigned 4 points. Empty stomachs are assigned the same number of points whether special methods or standard analysis methods are used.

Predators	Standard Points Full	Special Points Full	Points Empty
Pacific cod, Skates, Sleeper shark, Bigmouth sculpin	4	4	2
Pacific halibut, Sablefish, Myox species	3	4	1.5
Pollock, Hake, Rockfish, Small-mouth flatfish, misc.	2.4	4	1.2
Arrowtooth/Kamchatka flounder, Greenland turbot	2	4	1
Essential Fish Habitat Flatfish Project	N/A	6	2
N. Bering Sea/Chukchi Sea Samples	N/A	6	2

The rate of stomach analysis that is considered fully successful is equivalent to an average of 60 points per day. Thus, 60 points/day for 5 days/week and 41.6 weeks/year approximately gives a 12,500 point annual benchmark for fully successful performance without working on a special project. 12,500 points is the equivalent of 3,125 full cod stomachs or 5,208 full pollock stomachs.

If special studies take up 20% of the analyst's time, 10,000 points is the annual benchmark. 10,000 points is the equivalent of 2,500 full cod stomachs or 4,167 full pollock stomachs.

Survey participation can also take time away from working in the lab. This time will be added to the number of stomachs that are analyzed at a rate of 300 points per (7-day) week (or 42.86 points/day). So for a person doing a typical 21 day leg, they would get 900 additional stomach points.

Analysts keep track of their progress relative to these benchmarks using a spreadsheet to enter the number of full and empty stomachs in each point-category that they complete each day. These spreadsheets are turned in on a monthly basis.

Appendix F: References for Prey Identification

References we commonly use for the identification of Alaskan invertebrates and fishes to broad taxonomic categories.

Invertebrates

Barnes, R.D. 1980. Invertebrate Zoology. Saunders College. 1089pp. *(Good background in invertebrate biology; good descriptions of broad taxa. For updated version see Ruppert et al. (2004).)*

Blake, J.A., P.H. Scott, and A. Lissner (eds.). 1996. Taxonomic Atlas of the Benthic Fauna of the Santa Maria Basin and West Santa Barbara Channel. Santa Barbara Museum of Natural History. 305pp. *(West coast, and somewhat incomplete, although good photos, descriptions, and biology of inverts.)*

Kaestner, A. 1970. Invertebrate Zoology, Volume 3. Interscience Publishers. 523 pp. *(In NMML library - Old source but has some good pictures)*

Kessler, D.W. 1985. Alaska's Saltwater Fishes and Other Sea Life. Alaska Northwest Publishing Company. p.126-325. *(Good pictures of species more commonly found in trawls, although not complete.)*

Kessler, D.W. 2003. Alaska's Saltwater Fishes and Other Sea Life, Volume 2: Miscellaneous Invertebrates. National Marine Fisheries Service. On compact disk. *(Easy to use, with pictures and short descriptions of species more commonly found in trawls, although not complete. Hard copy of earlier version.)*

Kozloff, E.N. 1987. Marine Invertebrates of the Pacific Northwest. University of Washington. 511pp. *(Keys and some diagrams and pictures, few descriptions.)*

Meglitsch, P.A. 1967. Invertebrate Zoology. Oxford University Press. 961pp. *(In NMML Library - General text; includes terrestrial inverts)*

Pavlovskii, E.N. (ed.). 1966. Atlas of the Invertebrates of the Far Eastern Seas of the USSR. Academy of Science. USSR. Zool. Inst. 457pp. *(In NMML Library - A few species also in Alaska; some good black and white plates.)*

Pearse, V., J. Pearse, M. Buchsbaum, and R. Buchsbaum. 1987. Living Invertebrates. Blackwell Scientific Publications. 848pp. *(Invertebrate biology background, some good pictures and line drawings.)*

Rudy, P., and L.H. Rudy. 1983. Oregon Estuarine Invertebrates. U.S. Fish and Wildlife Service FWS/OBS-83/16, 225pp. *(Good descriptions and diagrams, although not complete for Alaska.)*

Ruppert, E.E., R.S. Fox, and R.D. Barnes. 2004. Invertebrate Zoology: A Functional Evolutionary Approach, 7th Edition. Brooks/Cole – Thomson Learning. 963pp. *(The most recent version of "Barnes" with updated information, organization, and internet sites by taxonomic group.)*

Smith, D.L. 1977. A Guide to Marine Coastal Plankton and Marine Invertebrate Larvae. Kendall/Hunt. p.1-135. *(Diagrams of invertebrate larvae)*

"Crustacean ID" binder. Photocopies from mixed sources on amphipods, euphausiids, mysids, crabs, and others. *(Keys, diagrams, and descriptions.)*

"Species Identification Manual". 1988. Compiled by Foreign Fisheries Observer Program, National Marine Fisheries Service. p.54-96. 2 copies. *(Intended for observers, although good for background, descriptions, and diagrams of some species.)*

"NMML Cephalopod Beak Collection". The National Marine Mammal Laboratory contact person for access to this collection is Jim Thomason (Jim.Thomason@noaa.gov).

Fishes

All. Cumulative. Blue, "Fish ID" Binder. *(Several pictures of bones and characteristics useful for identifying various groups of fishes.)*

Baxter, R. 1990. Annotated Key to the Fishes of Alaska. Center for Alaskan Studies. ~800pp. *(Very complete guide to Alaskan fishes, with fairly good meristics data.)*

Cannon, D.Y. 1987. Marine Fish Osteology: A Manual for Archaeologists. Department of Archaeology, Simon Fraser University. 133pp. *(3 copies - Good diagrams representative of a few families, although not complete.)*

Clothier, C.R. 1950. A key to some Southern California fishes based on vertebral characters. Calif. Fish. Bull. (79):83pp.

Fujita, K. 1990. The Caudal Skeleton of Teleostean Fishes. Tokai University Press. 897pp. *(Diagrams of tail bone structure, although not complete, and descriptions are in Japanese.)*

Grant, D., M. Gjernes, and N. Venables. 1996. A Practical Guide to the Identification of Commercial Groundfish Species of British Columbia. Archipelago Marine Research Ltd. 34pp. *(2 copies - Good pictures, but very incomplete.)*

Hart, J.L. 1973. Pacific Fishes of Canada. Fisheries Research Board of Canada. 740pp. *(Key, diagrams, and fairly complete descriptions of species.)*

Kessler, D.W. 1985. Alaska's Saltwater Fishes and Other Sea Life. Alaska Northwest Publishing Company. p.1-126. *(Good pictures of species more commonly found in trawls, although not complete.)*

Kessler, D.W. 2003. Alaska's Saltwater Fishes and Other Sea Life, Volume 1: (Fishes). National Marine Fisheries Service. On compact disk. *(Easy to use, with pictures and short descriptions of species, although not complete. Hard copy of earlier version on shelves.)*

Matarese, A.C., et al. 1989. Laboratory guide to early life history stages of Northeast Pacific fishes. NOAA Tech. Rep. NMFS-80. 652pp. *(Very good source for larval fish, with descriptions and diagrams.)*

Mecklenburg, C.W., T.A. Mecklenburg, and L.K. Thorsteinson. 2002. Fishes of Alaska. American Fisheries Society. 1037pp. *(Excellent, most up-to-date, very complete, although a few minor errors.)*

Morrow, J.E. 1977. Illustrated Keys to Otoliths of Forage Fishes of the Gulf of Alaska, Bering Sea, and Beaufort Sea. National Marine Fisheries Service. 69pp. *(Keys and diagrams of otoliths, can use to ID to family and/or species level.)*

Orr, J.W. 2002. Key to Jawless and Cartilaginous Fishes Encountered in the Northeast Pacific Groundfishery [and] Key to Families of Bony Fishes Encountered in the Northeast Pacific Groundfishery. Compilation. 21p. *(Keys to family level only, with some good diagrams.)*

Smith, D.L. 1977. A Guide to Marine Coastal Plankton and Marine Invertebrate Larvae. Kendall/Hunt Publishing Company. p.135-140. *(Diagrams of fish larvae - limited)*

Yang, M.S. 1993. Pictorial guide to the gill arches of some marine fishes in the North Pacific. National Marine Fisheries Service, AFSC Proc. Rep. 91-15 (see also J:\Foodlab\Taxonomy\gillarches\ ) *(Good pictures of gill arches.)*

"Species Identification Manual". 1988. Compiled by Foreign Fisheries Observer Program, National Marine Fisheries Service. p.1-54. 2 copies. *(Intended for observers, although good for background, descriptions, and diagrams of some species.)*

"NMML Fish Bone and Otolith Collection". The National Marine Mammal Laboratory contact person for access to this collection is Jim Thomason (Jim.Thomason@noaa.gov). A "FishBones" list by species is located in the Reference Specimen Collection binder.

References we commonly use for the identification of Alaskan invertebrates and fishes to narrow taxonomic categories, often to species.

Taxonomic Group	**NODC Code**

Cnidaria (jellyfish) **3700000000**

Wrobel, D., and C. Mills. 1998. Pacific Coast Pelagic Invertebrates: A Guide to the Common Gelatinous Animals. Monterey Bay Aquarium. 108pp. *(In NMML library. Good color pictures of living organisms, with descriptions.)*

Ctenophora (comb jellies) **3800000000**

Wrobel, D., and C. Mills. 1998. *(In NMML library*)

Polychaeta (polychaete worms) **5001000000**

Fauchild, K. 1977. The Polychaete Worms: Definitions and Keys to the Orders, Families, and Genera. Natural History Museum of LA County. 188pp. *(Good descriptions of taxonomic relationships, few pictures.)*

Page, B. 1995. Guide to Some of the Common Eastern Bering Sea Polychaetes. NMFS (Trophic Interactions). 27pp, plus additions from Geana Tyler. *(Good ID table, diagrams, descriptions of families.)*

Pleijel, F., and R.P. Dales. 1991. Polychaetes: British Phyllodocoideans, Typloscolecoideans, and Tomopteroideans. Linnean Soc. Of London and the Estuarine & Coastal Sciences Assoc. 202pp. *(Background.)*

Internet key: www.nhm.ac.uk/zoology/taxinf/index2.html *(Good source.)*

Gastropoda (snails) **5100000000**

MacIntosh, R.A. 1976. A Guide to Some Common Eastern Bering Sea Snails. National Marine Fisheries Service, Proc. Rep. 27pp. *(Good descriptions, mediocre pictures.)*

Kessler, D.W. 1985. Alaska's Saltwater Fishes and Other Sea Life. Alaska Northwest Publishing Company. 325p. *(Good pictures of species more commonly found in trawls, although not complete.)*

Kessler, D.W. 2003. Alaska's Saltwater Fishes and Other Sea Life, Volume 2: Miscellaneous Invertebrates. National Marine Fisheries Service. On compact disk. *(Easy to use, with pictures and short descriptions of species more commonly found in trawls, although not complete. Hard copy of earlier version.)*

Pteropoda **5109000000**

Wrobel, D., and C. Mills. 1998. *(In NMML library*)

Nudibranchia (sea slug) 5127000000

Wrobel, D., and C. Mills. 1998. *(In NMML library*)

Bivalvia (clams and mussels) 5500000000

Kessler, D.W. 1985 and 2003. *(Good pictures of species more commonly found in trawls, although not complete.)*

Cephalopoda (squid and octopus) 5700000000

Akimushkin, I.I. 1963. Cephalopods of the Seas of the U.S.S.R. Academy of Sciences of the U.S.S.R. 223pp. *(Diagrams of beaks, descriptions of families.)*

Clarke, M.R. (ed.). 1986. A Handbook for the Identification of Cephalopod Beaks. Clarendon Press, Oxford. 273pp. [Photocopy.] *(Good diagrams and keys. Original can be found in the NMML library.)*

Jorgensen, E.M. 2009. Field Guide to Squids and Octopods of the Eastern North Pacific and Bering Sea. Alaska Sea Grant College Program, University of Alaska Fairbanks. 93pp.

Nesis, K.N. 1982. Cephalopods of the World. VAAP Copyright Agency, Moscow. 351pp. [Photocopy.] *(Good keys, diagrams, and descriptions. Original can be found in the NMML library.)*

Roper, C.F.E., R.E. Young, and G.L. Voss. 1969. An Illustrated Key to the Families of the Order Teuthoidea (Cephalopoda.) Smithsonian Institution Press. 32pp. (*Photocopy quality-hard to read; diagrams of squids and descriptions of families.)*

Copepoda 6118000000

Gardner, G.A., and I. Szabo. 1982. British Columbia pelagic marine copepoda: An identification manual and annotated bibliography. Canadian Special Publication of Fisheries and Aquatic Sciences. 536pp. *(Keys, pictures and descriptions.)*

Mysidacea Mysida 6153000000

Kathman, R.D., et al. 1986. Identification Manual to the Mysidacea and Euphausiacea of the Northeast Pacific. Canadian Special Publication of Fisheries and Aquatic Sciences, Ottawa. p.21-245.. *(Keys, diagrams and descriptions.)*

Isopoda 6158000000

Schultz, G.A. 1969. The Marine Isopod Crustaceans. WM. C. Brown Co. Pub. 359pp. *(Keys and diagrams.)*

Amphipoda Gammaridea 6169000000

Staude, C.P. et al. 1977. An Illustrated Key to the Intertidal Gammeridean Amphipoda of Central Puget Sound. Fisheries, University of Washington. 27pp. *(Key and diagrams; incomplete for Alaska.)*

Amphipoda Hyperiidea 6170000000

Brusca, G.J. 1981. Annotated Keys to the Hyperiidea (Crustacea:Amphipoda) of North American Coastal Waters. Allan Hancock Foundation. 76pp. *(Keys and some diagrams.)*

Wing, B.L. 1976. Ecology of *Parathemisto libellula* and *P. pacifica* (Amphipoda:Hyperiidea) in Alaskan Coastal Waters. National Marine Fisheries Service, Proc. Rep. 266pp. *(Not good for ID purposes; mostly ecology.)*

Euphausiidae (krill) 6174020000

Kathman, R.D., et al. 1986. Identification Manual to the Mysidacea and Euphausiacea of the Northeast Pacific. Canadian Special Publication of Fisheries and Aquatic Sciences, Ottawa. p.247-411. (Keys, diagrams and descriptions.)

Mei-Sun Yang's Euphausiid ID (on-line J:\Foodlab\Taxonomy)

Natantia (shrimp) 6178000000

Butler, T.H. 1980. Shrimps of the Pacific Coast of Canada. Department of Fisheries and Oceans, Ottawa. 280pp. *(2 copies - Good keys, pictures, and descriptions of all shrimp families.)*

English, T.S. 1976. Aids for Identification of Early Life History Stages of Shrimps in Alaskan Waters. University of Washington. 31pp. *(Key and sketches of Pandalid larvae.)*

Kessler, D.W. 1985. *(Good pictures of species more commonly found in trawls, although not complete.)*

Reptantia (crabs) 6180000000

English, T.S. 1976. Aids for Identification of Early Life History Stages of Crabs in Alaskan Waters. University of Washington. 35pp. *(Key and sketches of larvae.)*

Hart, J.F.L. 1982. Crabs and Their Relatives of British Columbia. British Columbia Provincial Museum. 267pp. *(Key and line drawings of adults.)*

Kessler, D.W. 1985 and 2003. *(Good pictures of species more commonly found in trawls, although not complete.)*

Ophiuridea (Brittle Stars) 8126000000

Carlton, J.T. 2007. The Light and Smith Manual: Intertidal Invertebrates from Central California to Oregon. University of California Press; 4th Edition. p. 930-941.

Holothuroidea (sea cucumbers) 8170000000

Lambert, P. 1997. Sea Cucumbers of British Columbia, Southeast Alaska, and Puget Sound. Royal British Columbia Museum. 166 pp. *(Good descriptions and pictures.)*

Kessler, D.W. 1985 and 2003. *(Good pictures of species more commonly found in trawls, although not complete.)*

Urochordata (tunicates) 8400000000

Kessler, D.W. 1985 and 2003. *(Good pictures of species more commonly found in trawls, although not complete.)*

Thaliacea (pelagic salp) 8407000000

Wrobel, D., and C. Mills. 1998. *(In NMML library.)*

Larvacea 8413000000

Wrobel, D., and C. Mills. 1998. *(In NMML library.)*

Rajidae (skates) 8713040000

Kessler, D.W., and D.E. Stevenson. 2003 A field guide to the skates (Rajidae) of Alaska, Version 2003.1. [in brown folder] *(Good pictures and descriptions of most recent species classifications.)*

Stevenson, D.E., J.W. Orr, G.R. Hoff, and J.D. McEachran. 2007. Field Guide to Sharks, Skates, and Ratfish of Alaska. Alask Sea Grant College Program, University of Alaska Fairbanks. 77pp.

Osmeridae (smelts) 8755030000

Chapman, W.M. 1941. The osteology and relationships of the Osmerid fishes. J. Morphology 69(2):279-301.

Paralepididae (barracudinas) 8762070000

Harry, R.R. 1951. Deep-sea fishes of the Bermuda oceanographic expeditions (family Paralepididae). Zoologica 36(2):17-35.

Harry, R.R. 1953. Studies on the bathypelagic fishes of the family Paralepididae: survey of the genera. Pac. Sci. 7(2):219-249.

Myctophidae (lanternfish) 8762140000

Paxton, J.R. 1972. Osteology and relationships of the lanternfishes (family Myctophidae). Bull. Nat. Hist. Mus. LA. 81pp.

Gadidae (cods and allies) 8791030000

Mujib, K.A. 1967. The cranial osteology of the gadidae. J. Fish. Res. Bd. Can. 24(6):1315-1375.

Zoarcidae (eelpouts) 8793010000

Anderson, M.E. 1982. Revision of the fish genera *Gymnelus* Reinhardt and *Gymnelopsis* Soldatov (Zoarcidae), with two new species and comparative osteology of *Gymnelus viridus*. Nat. Mus. of Nat. Sci., Canada. Zoology (17):76pp.

Scorpaenidae (rockfish) 8826010000

Kramer, D.E. and V.M. O'Connell. 1988. Guide to Northeast Pacific Rockfishes. University of Alaska. 78pp. *(Good color pictures and descriptions.)*

Love, M.S., M. Yoklavich, and L Thorsteinson. 2002. The Rockfishes of the Northeast Pacific. University of California Press. 405pp. *(Good keys, taxonomic relationships, pictures, and ecological descriptions – Troy Buckley's personal copy).*

Orr, J.W., M.A. Brown, and D.C. Baker. 1998. Guide to Rockfishes (Scorpaenidae) of the Genera *Sebastes, Sebastolobus,* and *Adelosebastes* of the Northeast Pacific Ocean. NOAA Tech. Memo, NMFS-AFSC-95, 47pp. (*Good pictures and descriptions.)*

Cottoidei (sculpins) 8831000000

Allen, M.J. 1983. Sculpins of the Genus *Myoxocephalus* of the Bering Sea [and] Key to the genera of sculpins (Cottidae) in the Bering Sea. NRC/NOAA, National Marine Fisheries Service. *(Good diagrams and descriptions of different genera.)*

Pietsch, T.W. 1993. Systematics and distribution of cottid fishes of the genus *Triglops* Reinhardt (Teleostei: Scorpaeniformes). Zool. J. Lin. Soc. 109:335-393.

Kessler, D.W. 1985 and 2003. *(Good pictures of species more commonly found in trawls, although not complete.)*

Agonidae (poachers) 8831080000

Busby, M.S. 1998. Guide to the Identification of Larval and Early Juvenile Poachers (Scorpaeniformes: Agonidae) from the Northeastern Pacific Ocean and Bering Sea. NOAA Tech. Rep. NMFS-137, 88pp. *(Good diagrams and descriptions.)*

Kessler, D.W. 1985 and 2003. *(Good pictures of species more commonly found in trawls, although not complete.)*

Pleuronectiformes Pleuronectoidei (flatfish) 8857000000

Orr, J.W., D.C. Baker, and M.A. Brown. 2002. Key to the Flatfishes of Alaska. 15pp. *(Up to date key with good diagrams.)*

Orr, J.W., and A.C. Matarese. 2000. Revision of the genus *Lepidopsetta* Gill, 1862 (Teleostei: Pleuronectidae) based on larval and adult morphology, with a description of a new species from the North Pacific Ocean and Bering Sea. Fish. Bull., U.S. 98:539-582. *(Descriptions of different rock sole species.)*

Yang, M.S. 1988. Morphological differences between two congeneric species of Pleuronectid flatfishes: arrowtooth flounder, *Atheresthes stomias*, and Kamchatka flounder, *A. evermanni*. Fish. Bull., U.S. 86:608-611. *(Good explanation of the differences between the two species.)*

Polychaete References **5001000000**

Banse, K., and K.D. Hobson. 1974. Benthic errantiate polychaetes of British Columbia and Washington. Bull. Fish. Res. Board Can. 185: 111 p.

Hobson, K.D., and K. Banse. 1981. Sedentariate and archiannelid polychaetes of British Columbia and Washington. Can. Bull. Fish. Aquat. Sci. 209: 144 p.

Appendix G: Summary of Fish Characteristics

Table 1. A guide to morphological features and characteristics of commonly found prey-fish families in Alaskan waters. X = present, st = sometimes present, usu = usually.

This table was compiled by Beth Matta and Katie Dodd from a variety of sources. This summary of information may be helpful by quickly reducing the number of possible fish types to consider when identifying an unknown fish prey. Further identification can be aided by using sources indicated in Appendix F.

Although fairly complete, this table is a work in progress. Please feel free to keep track of information that you would like to see added to this table. Periodically, we will update the table with the new information (in the Document Management System's version of the Stomach Content Analysis Procedures Manual).

An electronic version of this table is available at \Taxonomy\Fish Guide.xls \Sheet = guide.

Table 1. A guide to morphological features and characteristics of commonly found prey-fish families in Alaskan waters.
X = present, st = sometimes present, usu = usually.

FISH GUIDE	Families of Fish	Rajidae (skates)	Clupeidae (herring + allies)	Salmonidae (salmon)	Osmeridae (smelts)	Bathylagidae (deepsa smelts)	Myctophidae (lanternfish)	Gadidae (cods + allies)	Zoarcidae (eelpouts)	Macrouridae (grenadiers)	Scorpaenidae (rockfish)	Hexagrammidae (greenlings)	Cottoidei (sculpins)	Agonidae (poachers)	Liparidae (snailfish)	Cyclopteridae (lumpsuckers)	Trichodontidae (sandfish)	Bathymasteridae (ronquils)	Stichaeidae (pricklebacks)	Cryptacanthodidae (wrymouths)	Zaproridae (prowfish)	Ammodytidae (sandlances)	Pleuronectidae (rt-eyed flatfish)
	Characteristics																						
Biology																							
Regions	Bering Sea	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Aleutians	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	GOA	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Depth	benthic	X						X	X	X	X	X	X	X	X	X	X		X	X	X	X	X
	pelagic		X	X	X	X	X	X	X			X			X	X							
External Features																							
Dorsal Fins	long base								X	X	X	X	st		X		X	X	X	X	X	X	X
	1		X	X	X	X	X		X		X	X		st	X	st		X	X	X	X	X	X
	2	X								X			X	X		X	X						
	3							X															
Pectoral Fins	large	X			st				X		X	X	X	X	X	X	X	X			X		st
	small		X	X		X	X	X	X	X										X			st
Anal Fin	absent	X																					
	long base				st	st	X		X	X		X	X	st	X			X	X	X	X	X	X
Pelvic Fins	absent/modified								st				st		X	X	X		st	X	X	X	
	long base																						
	abdominal		X	X	X	X																	
	thoracic						X	X		X	X	X	X	X	X		X	X	X		X		X
	jugular								X														
	anterior to dorsal				st		X	X	X	st			X	X									

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Adipose Fin	present			X	X	X	X																
Spines	preopercular										X		X				X						
	dorsal fin									X	X		X	X		X	X		X	X	X		
	pelvic fin										X		X	X									
	anal fin										X								X	X			
	other	X									X		X										
Scutes	dorsal																						
	ventral		X																				
	covering body												st	X		st							st
Lateral Line	absent		X						st														
	multiple								st			X									X		st
Tail Shape	long and tapering	X							X	X					st								
	forked		X		X	X	X					X	X				X					X	
	rounded in			X							X		X		st								
	rounded out											X	X	X	st	X		X	X	X	X		st
	truncate							X			X	X	X	X	st	X		X	X				st
	confluent w/dors.								X	X					st				st	X			
Body Shape	slender		X		X	X		X	X	X		X	st	X	st		X		X	X		X	
	stout						X				X		X			X					X		
	flattened	X													X						X		X
	long		X	X	X	X		X	X	X		X		X	X				X	X	X	X	
	short						X				X		X			X							

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Teeth	large			X	st							st			st		X						st
	small		X		X	X	X	X		X	X		X	X									st
	vomerine		st	X	X	X	st	X	usu		X		st					X		X			
	palantine		st	X	X	X	X		usu		X		st					X					
	tongue			X	X																		
Eye	large	X	X			X	X	st	st	X	X		X		st	X	X	X					
	small			X											st								
Photophores	present						X																
Mouth	large	X	X	X			X	X		X	X	st	X		st		X	usu			X		st
	small					X									st	X							st
	pointed up																X			X			
	pointed down	X																					
	terminal		X						st					st	usu	X		X	usu		X		usu
	overbite	X							X	X				st	st								
	underbite													st	st					X		X	
Adhesive Disc	present														X	X							

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	Characteristics																						
Internal Features																							
Peritoneum	darkly pigmentd		st		st	X	st	st	usu		st				st								
Vertebrae	<50 (roughly)					usu	X				X		X	X	X		X						X
	>50 (roughly)	X	X	X	X	st		X	X	X		X			X			usu	X	X	X	X	X
	paddle-like trunk							X	st					X									st
	precauds present		X	X							st	X	X	st					X			X	
	H-shape precaud		X																				
	tapering caudals							X	X	X													
Pyloric Caeca	many		X	X				X							X						X		
	few (approx<10)				X	X	X		X	st			X							X			
Otolith Shape	oval		X					X			X									X			
	round								X								X						
	large rostrum		X														X			st			
Gill Rakers	stubby								X	X	st	X	X	X		X	X		X	X			st
	spined								X	X			st						X			X	
	long + slender		X		X	X	X	X			X							X			X	X	st
	many (>40)		X					st			st												
	long upper arch		X	X	X	X																	